WATER USE BY SALTCEDAR AND ASSOCIATED VEGETATION

Results and Discussion

Canadian Location – Draw Down Recharge Method

Estimated water use for the Canadian location was similar for Wells 3 and 4 (slough), but lower for Well 2 (upland) (Table 32). Average daily water use at each well was highest in June and July and became lower in August and September. The stomatal resistance and high air temperatures in August and September appeared to cause the low daily water use. The lowest daily water use occurred in April and October.

Table 32. Estimated monthly and daily water use (meters) and standard deviation (STD) Canadian Location 2001.

Month	Well 2		Well 3		Well 4		Monthly Average (STD)
	Month	Day	Month	Day	Month	Day	
April (6 days)	0.0773	0.0129	0.0477	0.0080	0.1225	0.0204	0.0825 (0.0376)
May (31 days)	0.4972	0.0160	0.7056	0.0228	0.7192	0.0232	0.6407 (0.1244)
June (30 days)	0.6453	0.0215	1.1371	0.0379	1.0693	0.0356	0.9507 (0.2664)
July (31 days)	0.6435	0.0208	1.1037	0.0356	1.1709	0.0378	0.9726 (0.2871)
August (31 days)	0.3856	0.1244	0.7226	0.0233	0.6546	0.0211	0.5877 (0.1783)
September (30 days)	0.3146	0.0105	0.4609	0.0154	0.4683	0.0156	0.4145 (0.0866)
October (4 days)	0.0250	0.0062	0.0397	0.0099	0.0604	0.0151	0.0417 (0.0178)
Total	2.5885		4.2173		4.2650		3.6911 (0.9540)

Colorado Location – Draw Down Recharge Method

Estimated water use at Wells 1 and 2 at the Colorado location were different in 2000 (Table 33). The estimated water uses in 2001 were lower for Wells 1 and 3, but higher for Well 2 (Table 34). Well 2 had the highest estimated water use in 2000 and 2001. All wells had higher water use estimates in 2001 because the growing season was longer by 31 days.

The average daily water use at Wells 1 and 2, and 3 did not show evidence of seasonal changes as observed at the Canadian location during the 2001 growing season. During the 2001 growing season average daily water use at Wells 1 and 3 decreased after May. This suggested that the herbicide activity reduced the foliage after the plants attempted leaf out in the spring. The drift from the herbicide application also resulted in canopy reduction at Well 2.

Table 33. Estimated monthly and daily water use (meters) and standard deviation (STD)-Colorado Location 2000.

Month	Well 1		Well 2		Average (standard deviation)
	Month	Day	Month	Day	
May (31 days)	0.0591	0.0019	0.1891	0.0061	0.1241 (0.0920)
June (30 days)	0.0493	0.0016	0.1059	0.0035	0.0776 (0.0400)
July (31 days)	0.0536	0.0017	0.1275	0.0041	0.0905 (0.0521)
August (31 days)	0.0516	0.0017	0.1707	0.0055	0.1113 (0.0841)
September (30 days)	0.0480	0.0016	0.1613	0.0054	0.1045 (0.0802)
October (5 days)	0.0099	0.0020	0.0276	0.0055	0.0187 (0.0125)
Total	0.2715		0.7822		0.5270 (0.3612)

Table 34. Estimated monthly and daily water use (meters)-Colorado Location 2001*.

Month	Well 1		Well 2		Well 3	
	Month	Day	Month	Day	Month	Day
April (6 days)	0.0195	0.0033	0.0194	0.0032	0.0323	0.0054
May (31 days)	0.0709	0.0023	0.1772	0.0057	0.1198	0.0039
June (30 days)	0.0449	0.0015	0.2336	0.0078	0.0114	0.0004
July (31 days)	0.0337	0.0011	0.1347	0.0043	0.0088	0.0003
August (31 days)	0.0314	0.0010	0.0710	0.0023	0.0069	0.0002
September (30 days)	0.0343	0.0011	0.1005	0.0033	0.0203	0.0007
October (30 days)	0.0694	0.0023	0.1161	0.0039	0.0214	0.0007
Total	0.3041		0.8524		0.2209	

*Monthly average and standard deviation not computed because the area around Well 1 and part of the area around Well 3 were treated with herbicide at the end of the growing season in 2000.

Pecos Location – Draw Down Recharge Method

Estimated water uses for the 2001 growing season at the Pecos location at Site A Well 1 (Table 35) and Site B Wells 1, 2, and 3 (Table 36) were similar. Wells 1 and 3 were located in the riparian zone and Well 2 was located at the edge of the riparian zone. Well 5 at Sites A and B, located in the upland with only native vegetation, had the lowest estimated water use for this location. Well 2 at Site A had a much lower estimated water use than the other wells located in and at the edge of the saltcedar zone.

Table 35. Estimated monthly and daily water use (meters) and standard deviation (STD)-Pecos Location Site A 2001.

Month	Well 1		Well 2		Well 3*		Well 5		Monthly Average (standard deviation)**
	Month	Day	Month	Day	Month	Day	Month	Day	
April (6 days)	0.0693	0.0115	0.0186	0.0031			0.0002	0.0000	0.0439 (0.0358)
May (31 days)	0.6482	0.0209	0.2407	0.0078			0.0014	0.0000	0.4444 (0.2880)
June (30 days)	0.6910	0.0230	0.2462	0.0082			0.0080	0.0003	0.4688 (0.3146)
July (31 days)	0.7082	0.0228	0.1907	0.0062			0.0104	0.0003	0.4496 (0.3661)
Aug. (31 days)	0.5458	0.0176	0.1377	0.0044			0.0088	0.0003	0.3417 (0.2886)
Sept. (30 days)	0.2765	0.0092	0.0794	0.0026			0.0065	0.0002	0.1780 (0.1393)
Oct. (4 days)	0.0206	0.0052	0.0052	0.0013			0.0006	0.0001	0.0129 (0.0109)
Total	2.9596		0.9185				0.0358		1.9385 (1.4448)

*No data for Well 3, ** does not include Well 5

Table 36. Estimated monthly and daily water use (meters) and standard deviation (STD)-Pecos Location Site B 2001.

Month	Well 1		Well 2		Well 3		Well 5		Monthly Average (standard deviation)*
	Month	Day	Month	Day	Month	Day	Month	Day	
April (6 days)	0.0464	0.0077	0.3076	0.0513	0.0758	0.0126	0.0020	0.0003	0.4700 (0.1433)
May (31 days)	0.5533	0.0178	1.3805	0.0445	0.6603	0.0213	0.0209	0.0007	0.8647 (0.4499)
June (30 days)	0.2825	0.0094	0.6494	0.0216	0.9097	0.0303	0.0305	0.0010	0.6139 (0.3152)
July (31 days)	0.4153	0.0134	0.2102	0.0068	0.8497	0.0274	0.0261	0.0008	0.4916 (0.3264)
Aug. (31 days)	0.6105	0.0197	0.0903	0.0029	0.2840	0.0092	0.0359	0.0012	0.3283 (0.2630)
Sept. (30 days)	0.6444	0.0215	0.0905	0.0030	0.1078	0.0036	0.0122	0.0004	0.2810 (0.3149)
Oct. (4 days)	0.0794	0.0199	0.0149	0.0037	0.0307	0.0077	0.0007	0.0002	0.0417 (0.0336)
Total	2.6317		2.7434		2.9180		0.1282		2.7642 (0.1442)

* Does not include Well 5

EPA Paired Plot Technique

Study design and applied treatments at the Colorado location enabled evaluation of further methods to estimate water use. A regression analysis was run on the smoothed data for Well 1 and Well 2 groundwater levels for May 1, 2000 through October 5, 2000. The regression equation was then used to predict what Well 1 water levels should have been in 2001 if the area had not been sprayed. The regression equation was

Well 1 = 0.533 + 0.753 Well 2. The actual values minus the predicted values indicated that the average daily water table levels during the growing season were 0.0396 meters higher in 2001 than they would have been if the area had not been treated (Fig. 28). The regression predicted daily water levels for Well 1 were used in the Draw Down

Recharge Method to determine what the daily water use would have been if the treatment had not been applied (Fig. 29). The actual average daily water use was 0.0014 m and the predicted average daily water use was 0.0036 m. The difference of 0.0022 m/day was water "saved" due to treatment. The growing season total for actual water use was 0.1679 m and the predicted growing season water use was 0.5722 m, a savings of approximately 0.4043 m.

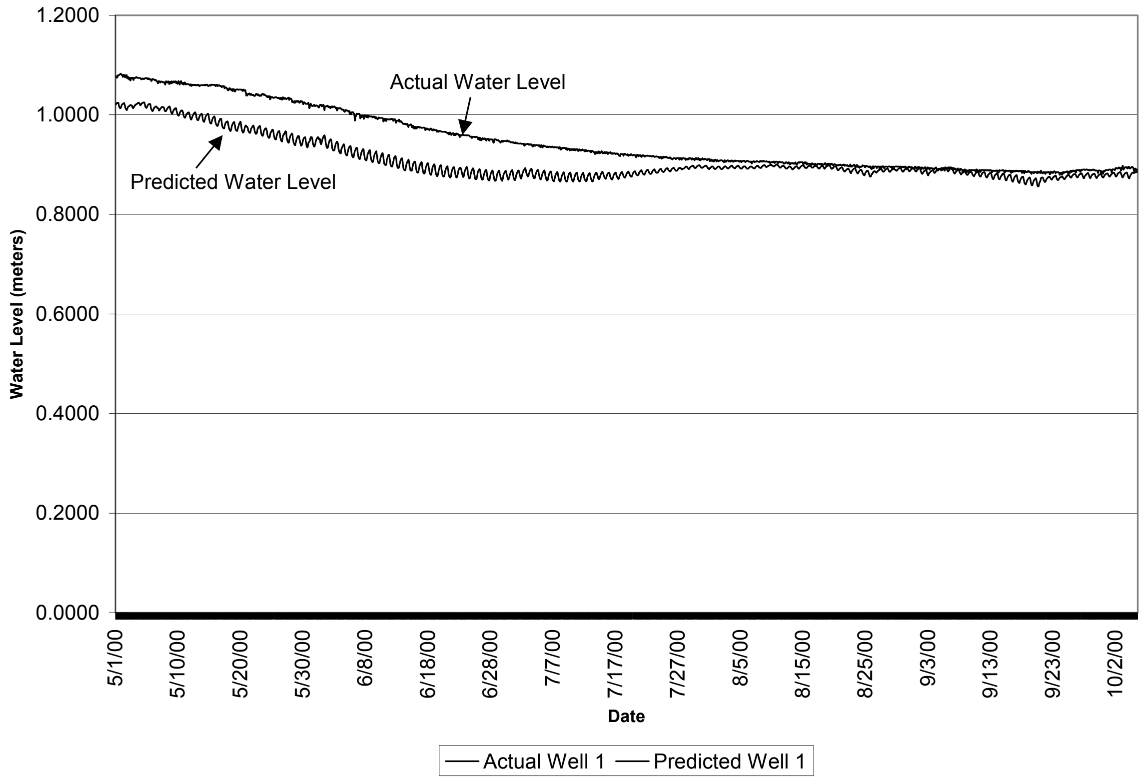

Fig. 28. Regression predicted water levels (based on 5/1 - 10/5, 2000 data) and actual water levels for Well 1 Colorado location (5/1 - 10/5, 2001).

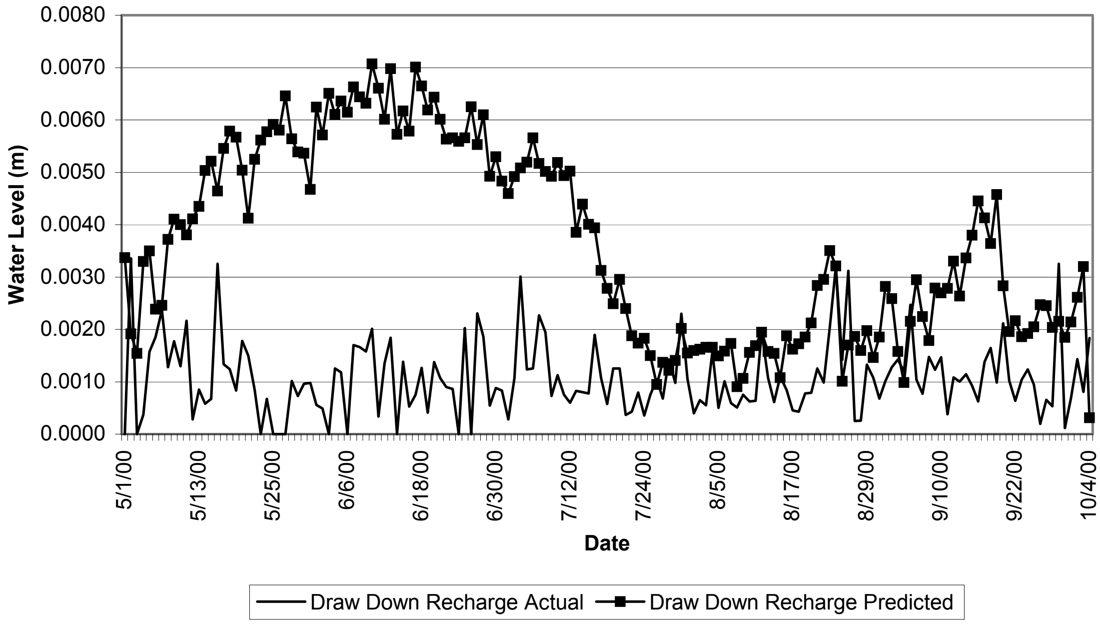

Fig. 29. Estimated daily water use by the Draw Down Recharge Method on actual and predicted data for Well 1 at the Colorado location (5/1 -10/5, 2001).

Potential Evapotranspiration

Daily potential evapotranspiration (PET) data was obtained from a weather station located in Sweetwater, Texas that was approximately 80 kilometers from the Colorado location. The PET was calculated using the Penman-Monteith method. The daily water use results from Well 2 at the Colorado location for April 25, 2001 through October 30, 2001 were compared to the PET data for the same day. A regression/correlation analysis was performed for the same day, for one day prior and one day past (i.e. estimated water use always began on 4/25 and PET began on 4/24, 4/25, and 4/26) for the PET data. This was done to see if there was any lag effect. The results of this analysis were R^2 of 0.33, R^2 of 0.23, and R^2 of 0.16 for one day prior, same day, and one day past respectively.

Draw Down Recharge Method - With Modified Recharge Rate

Considering White's (1932) argument on recharge rate, a modification was made to Method 4 to evaluate the use of (*r*) calculated as the recharge rate for 4 hours preceding the current days high. However, in Method 6 the recharge rate was calculated from 12:00 a.m. to 4:00 p.m.

Water levels for June 2001 Well 2 at the Colorado location were used to calculate water use with the new recharge rate. Results showed the original Method 4 water use to be 0.2336 m compared to 0.1940 m for June 2001 using "White's" (*r*) concept. The calculated recharge rate was lower than the original Draw Down Recharge Method calculation. This analysis was conducted to determine how changing the recharge rate would affect water use estimates.

Conclusions

The estimated water use at the Canadian location was different between wells. Well 3 and 4 had similar water uses that were both greater than Well 2. Data suggest this was a result of Wells 3 and 4 being located in a slough with dense vegetation. Wells 3 and 4 at the Canadian location had the highest water uses of all wells and all locations. Probably due to the shallow water table and dense understory/overstory vegetation.

Well 2 had the highest water use at the Colorado location in 2000 and 2001. The water use declined between years (May - September 2000 and 2001) for Wells 1 and 2 at this location. This was believed to be the result of the herbicide application, which killed approximately 49% of the saltcedar plants around Well 1. The Colorado location had the lowest estimated water use among the three study locations due to the depth to the water table, young saltcedar, and low specific yield.

The estimated water use for the wells at the Pecos location were similar for Site A Well 1 and Site B Wells 1, 2, and 3. However, Well 5 at both Sites A and B had much lower water use estimates, and Well 2 Site B had a much higher water use estimate than Well 2 at Site A. Well 5 at both sites was much lower because the wells were located in the upland and had low specific yields, surrounded by mesquite and fourwing saltbush, and had a greater depth to the water table. The difference in the water use estimates between Well 2 at both sites could not be determined.

The daily water use estimates for all wells at all locations are lower at the beginning of the growing season and increase until August, at which time they begin to decline. This suggests that the saltcedar is not using as much water when the temperatures begin to rise in the summer. Van Hylckama (1969) found that saltcedar was temperature sensitive and reduced its water use on hot afternoons. Anderson (1977) found that the optimum leaf temperatures for saltcedar photosynthesis were between 23° and 28°C, and that stomatal resistance in saltcedar increased as leaf temperatures increased between 14° and 50°C.

The EPA Method was used to determine if there was a difference in water levels at Well 1 at the Colorado location after applying a herbicide treatment. The daily water levels were higher in Well 1 the year following herbicide application. This was attributed to the fact that the saltcedar was no longer using as much water after being treated.

The predicted data from the EPA method was used in the Draw Down Recharge Method to determine if there was a difference in estimated water use between the actual and predicted water levels at Well 1 at the Colorado location. The data suggests that the actual growing season water use was 0.2162 meters and the predicted water use would have been 0.5722 meters. This suggests that the herbicide treatment lowered the water use at Well 1 by 0.3560 meters.

The PET investigation did not show a strong correlation between estimated daily water use and weather station data. This was probably due to the fact that the weather station data was obtained from a location a considerable distance from the study location.

The modified Draw Down Recharge Method study was done to determine if the method for calculating recharge, described by Walter N. White (1932), was "better" than the recharge rate calculation in the Draw Down Recharge Method. The results showed that the estimated water use would be lower using the White (1932) method of calculating recharge. This is logical because the recharge rate in the modified Draw Down Recharge Method was calculated at the top of the diurnal curve when recharge rates were lower, further confirming that the original Draw Down Recharge Method was probably the "best" approach to date. This evaluation of recharge rate calculation helped identify Draw Down Recharge Method as the "best" calculation method because the recharge rate in the Draw Down Recharge Method was calculated from the low to the next high water level; thus, giving a better estimate of water use for these systems. Therefore White's (1932) recharge rate estimate does not reflect the average recharge rate while transpiration is occurring and this method would be too conservative under the conditions of this study.